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Signed *Andrew Gersey*

Dated 19 January 2000

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The Patent Office

Cardiff Road  
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1. Your reference

REP05974GB

2. Patent application number

(The Patent Office will fill in this part)

22 DEC 1998

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Microscience Ltd.  
67-68 Jermyn Street  
London  
SW1Y 6NY  
United Kingdom

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

07304546001

4. Title of the invention

PROTEIN AND COMPOSITIONS CONTAINING IT

5. Name of your agent (if you have one)

GILL JENNINGS & EVERY

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Broadgate House  
7 Eldon Street  
London  
EC2M 7LH

Patents ADP number (if you know it)

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Country

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Date of filing  
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor
  - b) there is an inventor who is not named as an applicant, or
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# Patents Form 1/77

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Continuation sheets of this form

Description

6

Claim(s)

1

Abstract

Drawing(s)

1

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11. For the Applicant  
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date

*Lucy Samuels*

22 December 1998

12. Name and daytime telephone number of person to contact in the United Kingdom

PERRY, Robert Edward  
0171 377 1377

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PROTEIN AND COMPOSITIONS CONTAINING IT

Field of the Invention

This invention relates to one protein, to vaccines  
5 containing it, and to its use in therapy, for immunisation.

Background to the Invention

Group B Streptococcus (GBS), also known as  
*Streptococcus agalactiae*, is the causative agent of various  
conditions. In particular, GBS causes:

10 *Early onset neonatal infection.*

This infection usually begins in utero and causes  
severe septicaemia and pneumonia in infants, which is  
lethal if untreated and even with treatment is associated  
with a 10-20% mortality rate.

15 *Late onset neonatal infection.*

This infection occurs in the period shortly after  
birth until about 3 months of age. It causes a  
septicaemia, which is complicated by meningitis in 90% of  
cases. Other focal infections also occur including  
20 osteomyelitis, septic arthritis, abscesses and  
endophthalmitis.

*Adult infections.*

These appear to be increasingly common and occur most  
commonly in women who have just delivered a baby, the  
25 elderly and the immunocompromised. They are characterised  
by septicaemia and focal infections including  
osteomyelitis, septic arthritis, abscesses and  
endophthalmitis.

*Urinary tract infections.*

30 GBS is a cause of urinary tract infections and in  
pregnancy accounts for about 10% of all infections.

*Veterinary infections.*

GBS causes chronic mastitis in cows. This, in turn,  
leads to reduced milk production and is therefore of  
35 considerable economic importance.

GBS infections can be treated with antibiotics.  
However, immunisation is preferable. It is therefore

desirable to develop an immunogen that could be used in a therapeutically-effective vaccine.

#### Summary of the Invention

According to the present invention, a partial GBS gene  
5 sequence, pho2-2, has been found which represents an ATP-binding protein.

In one aspect of the invention, the use of this protein in a recombinant protein vaccine is described. This vaccine may be administered to females either prior to  
10 or during pregnancy to protect mother and neonate against infection by GBS.

The gene sequence may be first genetically altered to increase the antigenicity of the encoded protein.

#### Brief Description of the Drawings

15 The invention will now be described in detail with reference to the accompanying figures, wherein:

Figure 1 shows the nucleotide sequence of the insert of clone pho2-2 and the deduced amino acid sequence of ORF2-2.

#### 20 Description of the Invention

Because of its extracellular or cell surface location, the protein of the present invention may be a suitable candidate for the production of therapeutically-effective vaccines against GBS. The term "therapeutically-effective"  
25 is intended to include the prophylactic effect of the vaccines. For example, a recombinant protein may be used, as an antigen for direct administration to a patient. The protein may be isolated directly from GBS expressed in any suitable expression system, e.g. *Lactococcus lactis*. It is  
30 preferably administered with an adjuvant, e.g. alum.

The protein may be a mutant protein, in comparison to wild-type protein, a fragment of the protein or a combination of different fragments, provided an effective immune response is generated.

35 An alternative approach is to use a live attenuated GBS vaccine. This may be produced by deleting the gene that encodes the protein. Preferably, the GBS strain

comprises additional virulence gene mutations.

The protein (or fragments thereof) of the present invention may also be used to produce monoclonal and polyclonal antibodies for use in passive immunisation.

5 In a further embodiment of the invention, the protein or corresponding polynucleotide may be used as a target for screening potentially useful drugs, especially antimicrobials. Suitable drugs may be selected for their ability to bind to the protein to exert their effects.  
10 Assays for screening for suitable drugs and which make use of the protein of the invention will be apparent to those skilled in the art.

Although the protein has been described for use in the treatment of patients, veterinary uses of the protein are  
15 also considered to be within the scope of the present invention. In particular, the protein or the vaccines may be used in the treatment of chronic mastitis, especially in cows.

The present invention is described with reference to  
20 Group B Streptococcal strain M732. However, all the GBS strains and many other bacterial strains are likely to include related proteins having amino acid sequence homology with the protein of M732. Organisms likely to contain the proteins include, but are not limited to, *S.*  
25 *pneumoniae*, *S. pyogenes*, *S. suis*, *S. milleri*, Group C and Group G *Streptococci* and *Enterococci*. Vaccines to each of these may be developed in the same way as described for GBS.

Preferably, the proteins that may be useful for the  
30 production of vaccines have greater than 40% sequence similarity with the protein of M732. More preferably, the proteins have greater than 60% sequence similarity. Most preferably, the proteins have greater than 80% sequence similarity.

35 The protein of the present invention was identified as follows:

A partial gene library of GBS (strain M732)

chromosomal DNA was prepared using the plasmid vectors pFW-*phoA1*, pFW-*phoA2* and pFW-*phoA3* (Podbielski, A. et al. 1996. Gene 177:137-147). These plasmids possess a constitutive spectinomycin adenyltransferase antibiotic resistance  
5 marker, which confers a high level of spectinomycin resistance and is therefore easily selected. Furthermore, these vectors contain a truncated (leaderless) *Escherichia coli phoA* gene for alkaline phosphatase. The three vectors differ only with respect to the reading frame in which the  
10 leaderless *phoA* gene exists, as compared to an upstream in-frame *Bam*HI restriction enzyme site. Because this truncated *E. coli phoA* gene lacks the appropriate leader sequence for export of this enzyme across the bacterial membrane, extracellular alkaline phosphatase activity is  
15 absent when these plasmids are propagated in an *E. coli phoA* mutant (e.g. strain DH5 $\alpha$ ). The chromogenic alkaline phosphatase substrate, XP (5-Bromo-4-chloro-3-indolyl-phosphate), does not enter intact bacterial cells and therefore only exported or surface associated alkaline  
20 phosphatase activity can be detected. When exported or surface associated alkaline phosphatase activity is present, the chromogenic XP substrate is cleaved to yield a blue pigment and the corresponding bacterial colonies can be identified by their blue colour.

25 Plasmid DNA was digested to completion with *Bam*HI and dephosphorylated using shrimp alkaline phosphatase. GBS genomic DNA was partially digested with *Sau*3AI, size fractionated on a sucrose gradient and fragments <1kb in size were ligated into the prepared pFW-*phoA* vectors. *E.*  
30 *coli* strain DH5 $\alpha$  was chosen as the cloning host since it lacks a functional *phoA* gene. Recombinant plasmids were selected on Luria agar containing 100  $\mu$ g/ml of spectinomycin and 40  $\mu$ g/ml of the chromogenic XP substrate. *E. coli* transformants harbouring plasmids containing GBS  
35 insert DNA that complements the export signal sequence of the leaderless *phoA* gene were identified by the blue colour of the colonies. Approximately 30000 different recombinant



plasmids containing GBS insert DNA were screened in this manner and 83 recombinant plasmids, which complemented the leaderless *phoA*, were chosen for further study.

From these experiments, one clone was selected containing a plasmid designated pho2-2. This plasmid contained a gene (or part thereof), which complemented the leaderless *phoA*. Plasmid pho2-2 contained 244 bp of GBS DNA and the nucleotide and deduced amino acid sequences are shown in Figure 1.

10 A comparison of the amino acid sequence of ORF2-2 was performed and the results are shown in Table 1.

As shown in Table 1, homologues to the GBS ORF2-2 gene product can be identified in *Enterococcus faecalis*, *Escherichia coli*, *Bacillus subtilis*, *Haemophilus*  
15 *influenzae*, *Streptococcus pyogenes*, *Streptococcus pneumoniae* and *Salmonella typhimurium*. The *E. faecalis*, *S. pyogenes* and *S. pneumoniae* homologues were identified from genome sequence data and no annotations were available as to the identity of the gene or gene products. In all other  
20 cases, homologues represented ATP-binding transport proteins that are part of ABC type transporters. Many of the components of ABC type transporters are membrane or cell surface associated, as these systems are involved in the transport of macromolecules from the extracellular  
25 environment to the intracellular compartment.

Table 1. Database search results for ORF2-2 (42 amino acids)

Organism	Protein Accession	DNA Accession	Gene Name	% Similarity	% Identity	Alignment Length
<i>E. faecalis</i>	bp 3266-3675	Contig 6377	Unknown	70.00	55.00	40
<i>E. coli</i>	SW:P02914	EM:J01648	malk	64.10	46.15	39
<i>B. subtilis</i>	TR:O34677	EM:Z99117	glnQ	56.76	45.95	37
<i>H. influenzae</i>	SW:P45171	EM:U32813	potA	54.76	45.24	42
<i>S. pyogenes</i>	bp 1286-2023	Contig 241	Unknown	51.22	43.90	41
<i>S. pneumoniae</i>	bp 1826-2833	Contig 4346 (rev)	Unknown	64.86	43.24	38
<i>S. typhimurium</i>	SW:P19566	EM:X54292	malk	61.54	41.03	39
<i>H. influenzae</i>	SW:P44692	EM:U32734	yebM	59.52	40.48	42
<i>E. coli</i>	SW:P37009	EM:D83536	afuC	52.38	38.09	42

CLAIMS

1. A surface-associated ATP-binding protein obtainable from a Group B streptococcal strain.
2. A protein according to claim 1, obtainable from the  
5 Group B streptococcal strain M732.
3. A protein according to claim 2, encoded by the polynucleotide defined as ORF2-2 in Figure 1 or a homologue thereof with at least 60% sequence homology.
4. A protein according to claim 3, wherein ORF2-2  
10 comprises the nucleotides 117-242.
5. A protein according to any of claims 1 to 4, for use in a method of therapy.
6. A protein according to claim 5, for use in the treatment of GBS infection.
- 15 7. A polynucleotide which encodes a protein according to any preceding claim, its complement, or a fragment thereof.
8. The use of a bacterial protein having amino acid sequence similarity with a protein according to any of claims 1 to 6 and which is surface associated, in the  
20 manufacture of a vaccine to treat bacterial infection.
9. The use according to claim 8, wherein the infection is a Group B streptococcal infection.
10. The use according to claim 8 or claim 9, wherein the infection is a focal infection.
- 25 11. The use according to claim 8 or claim 9, wherein the infection is a urinary tract infection.
12. Use of a product according to any of claims 1 to 7, for screening potential antimicrobial drugs.
13. An antimicrobial drug selected using the products as  
30 defined in claim 12.
14. A vaccine comprising a protein according to any of claims 1 to 6 and 8.
15. A vaccine comprising a microorganism having a virulence gene deletion, wherein the gene codes for a  
35 protein according to claim 8.
16. An antibody raised against a protein according to any of claims 1 to 4.

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Figure 1. Nucleotide and deduced amino acid  
sequence of clone pho2-2

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      10              30              50
GATCGGGCGCAAGCTTAACGATTCTTTTAAAATCATTAAATTTTAAAAC

      70              90
AAATTCAGACATATTGCCAAAGTTTTGATATTATTACTATAATATAGTT
      START ORF2-2
     110      |      130              150
TG TAGAGGAGAATAATATGGGCCAAGAACCTATCATCGAATATCAAAATA
      M  G  Q  E  P  I  I  E  Y  Q  N  I

      170              190
TCAATAAAGTGTATGGGGAAAATGTTGCGGTTGAAGATATTAACCTTAA
      N  K  V  Y  G  E  N  V  A  V  E  D  I  N  L  K

     210              230
ATTTACCCTGGTGATTTTCGTTTGTTCATCGGTACGAGTGGATC 244
I  Y  P  G  D  F  V  C  F  I  G  T  S  G
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